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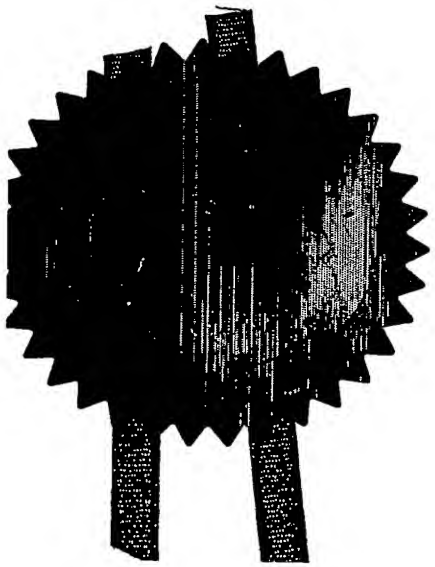

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Your reference	DAW1215
	21 JAN 2004
Patent application number *(The Patent Office will fill in this part)*	0401198.7
Full name, address and postcode of the or of each applicant *(underline all surnames)*	IMI Vision Limited Tything Road Arden Forest Industrial Estate Alcester Warwickshire B49 6EU
	21JAN04 E866800-2 D02806 P01/7700 0.00-0401198.7 CHEQUE
Patents ADP number *(if you know it)*	8385171002
If the applicant is a corporate body, give the country/state of its incorporation	England
Title of the invention	Fluid Metering
Name of your agent *(if you have one)*	Barker Brettell
"Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*	138 Hagley Road Edgbaston Birmingham B16 9PW
Patents ADP number *(if you know it)*	7442494002

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Description 10 + 10

Claim(s)

Abstract 1

Drawing(s) 6 + 6

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Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*

Request for preliminary examination *(Patents Form 9/77)*

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11. I/We request the grant of a patent on the basis of this application.

Signature Barker Brettell Date 20 January 2004

12. Name and daytime telephone number of person to contact in the United Kingdom

Barker Brettell

David A. Wightman Tel: 0121 456 1364

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FLUID METERING

This invention relates to improvements in fluid metering, and especially but not exclusively to the sanitary metering of very viscous fluids, for example beverage concentrates.

In the food sector, for example, there is often a requirement to dispense a metered amount of fluid foodstuff for use as such or in admixture with a diluent such as water. It is becoming increasingly important to be able to dispense fluids in a sanitary manner where there is no possibility of outside contamination of the fluid foodstuff or where companies want to be able to assure the integrity of the fluid being dispensed. Commonly, the fluid foodstuff is supplied in a disposable container. For sanitary requirements to be met, it is desirable that the fluid contacts only disposable parts of the system, including the pump used to dispense the fluid. For this to be economically viable, the pumping method should be simple and so relatively inexpensive to produce.

In food dispense, and particularly in the beverage industry, there is a common requirement to dispense an accurate ratiometric mixture of a concentrate and a diluent. Common technologies involve measuring the flow of the concentrate and then varying the diluent flow to achieve the correct mixture. This has the disadvantage that it involves measuring the fluid flow of, in particular, the concentrate. Common methods include the use of turbine flow meters and differential pressure flow meters. These techniques are however not effective for measuring the flow of a highly viscous concentrate such as an orange juice concentrate. Current methods of dealing with these viscous fluids are to meter them using peristaltic pumps or diaphragm type pumps integrated into manifolds. While these methods work well for many relatively viscous fluids, they do not work well for very highly viscous fluids. For example, peristaltic

type pumps typically become less effective for fluids having a viscosity in excess of about 5000 centipoises. Non-disposable diaphragm pumps can be effective for dispensing very viscous fluids but the manifold valving arrangements for disposable sanitary diaphragm pumps are commonly such that the fluid drag renders them unsuitable for use with very viscous fluids.

Examples of disposable sanitary diaphragm pump designs are proposed in US Patent 6,485,263. However, these designs either utilise somewhat tortuous fluid inlet paths (e.g. as shown in Figure 10) or they utilise solenoid valves (e.g. as shown in Figure 1) that are intended to be disposed of with the other disposable pump components. The tortuous inlet path shown in the Figure 10 proposal would create considerable drag on a highly viscous fluid and hinder the performance of the pump. This problem could be overcome by pressurising the source of fluid that is being dispensed by applying pressure internally to the fluid reservoir or by having a flexible reservoir and applying pressure externally. However, in sanitary systems, it is not acceptable to apply internal pressure and to apply pressure externally involves a much more complex and expensive system. The use of solenoid valves in the pump unit intended to be disposed of, as shown in Figure 1, has the disadvantage that they are expensive.

It is the purpose of the present invention to provide an improved sanitary fluid metering device which incorporates a relatively cost-effective disposable pump arrangement and which is capable of metering a highly viscous fluid.

According to the present invention, there is provided a disposable pump unit for receiving and metering a predetermined volume of fluid, the pump comprising a body having a surface at which opens the mouth of a

cavity formed in the body, an inlet port for the fluid opening at the surface adjacent to the mouth of the cavity whereby, when the inlet port is open, fluid can flow from the inlet port into the cavity *via* the mouth thereof, a first flexible membrane sealingly secured at its periphery to the surface and overlying the cavity and the inlet port, an outlet port for the fluid, there being a fluid flow passageway extending through the body connecting the cavity to the outlet port, and a second flexible membrane sealingly secured at its periphery and overlying the outlet port, those portions of the first and second flexible membranes, where they overlie the inlet and outlet ports respectively, serving as closures for the ports.

The outlet port preferably also opens at the aforesaid surface, in which case the first and second flexible membranes may be integral with one another. The membranes preferably comprise flexible and durable film or sheet polymer, for example low density polyethylene, although a variety of alternative materials could be used.

In use, a disposable pump unit of the invention is detachably coupled to a re-usable pump actuator, with the said surface sealingly abutting the pump actuator, comprising a source of positive and negative pressure actuating fluid, preferably air, and first and second valve actuating means associated respectively with the inlet port closure and the outlet port closure, the arrangement being such that, when the external surface of the first flexible membrane (which acts as a pumping membrane) is exposed to the source of negative pressure fluid, with the inlet port open and the outlet port closed, it is drawn away from the disposable pump body whereby fluid, such as a beverage concentrate, is drawn, from a reservoir thereof *via* the inlet port, into substantially all of the space defined by the cavity and the first flexible membrane ("the fluid filling step"). Then, with the inlet port closed and the outlet port open, when positive pressure fluid is applied to the external surface of the first flexible membrane, the

membrane is urged back towards and into the cavity and pumps the fluid from the cavity through the said passageway to the outlet port ("the fluid metering step"). There may be a variable downstream flow restrictor to enable the same fluid metering rate to be achieved for different viscosity fluids with the application of the same positive actuating fluid pressure. Alternatively, the fluid pressure could simply be varied.

Preferably, a disposable pump unit of the invention comprises a body having a plurality of cavities each having respective inlet ports, outlet ports and flexible membranes whereby, when coupled to a pump actuator, fluid may be drawn into at least one of the cavities whilst simultaneously being pumped out of another. In this way, the unit may, where required, be used to meter varying predetermined volumes of fluid in a substantially continuous and efficient way. Preferably, the body has a pair of cavities. Where there is a plurality of cavities, the simultaneous fluid filling and fluid metering steps may be of different duration such that when one dispensing step from one of the cavities is complete the other is ready to commence, or has already commenced, its dispensing step; this may be achieved by, for example, suitably adjusting the negative and positive actuating fluid pressures by means of adjustable pressure regulators.

The combination of a disposable pump unit of the invention and a re-usable pump actuator may constitute a beverage dispenser, the pump unit serving to meter a predetermined amount of a beverage concentrate, for example orange concentrate, which is then mixed with water, preferably in a predetermined ratio, delivered by the dispenser. For that purpose in particular, the body of the disposable pump unit preferably incorporates a diluent, e.g. water, inlet communicating with an outlet passageway formed in the body connected to the outlet port whereby, as fluid flows from the outlet port through the outlet passageway, it mixes with the diluent and is then dispensed into a receptacle such as a cup or glass. The

outlet passageway preferably includes means, for example a static turbulator, to assist the admixture of the fluid and diluent. Further, there may be provided means to adjust the diluent flow rate and feedback means so as to ensure constant ratiometric mixing.

The pump actuator includes a complementary surface that abuts the aforesaid surface of the disposable pump unit. Both surfaces are preferably substantially planar. An essential function of the pump actuator surface is to control the degree to which the first flexible membrane can be drawn away from the disposable pump body and therefore in part to define the predetermined metered volume of fluid. Preferably, the surface of the pump actuator also has at least one cavity (the number corresponding to the number of cavities in the disposable pump body) defined in it for receiving the first flexible membrane during the fluid filling step, the cavity wall serving to limit movement of the membrane. The cavity(ies) of the disposable pump unit and (if any) of the pump actuator are preferably concave in form.

Another function of the pump actuator is to provide actuating means for the closures of the inlet and outlet ports. The actuating means preferably comprise respective solenoid-operated armatures which, by means of a compression spring, urge part of the respective flexible membrane into sealing contact with the inlet or outlet port in order to close it, but which assume, when the solenoid is energised, a spaced position from the membrane when the port is required to be open. Alternatively, for example, the armatures may be pneumatically operated. In order to improve the fluid seal between the ports and the flexible membranes in the port-closed position, each port is preferably surrounded by a raised lip.

The disposable pump unit is preferably permanently connected to, or integral with, a reservoir containing the fluid so that, once the reservoir is empty or otherwise needs to be changed, the combined reservoir and pump unit are disconnected from the pump actuator and may be disposed of. A replacement reservoir/pump unit may then be connected to the pump actuator. Especially in the drinks dispense context, the reservoir is preferably refrigerated by a refrigeration system comprised in the re-usable part of a drinks dispense machine and which also serves to cool any water diluent.

It will be appreciated that the metered fluid comes into contact with only components of the disposable pump unit and, therefore, that the pump actuator may/can be continually re-used without the need to clean it regularly. Thus, the pump actuator will be part of, for example, a fixed drinks dispense machine installed in a bar, restaurant or the like, it being possible for a given machine to dispense different beverages depending on the nature of the fluid concentrate contained in a selected reservoir/disposable pump unit. Because different concentrates will usually require different degrees of dilution, the machine preferably includes means for recognising the identity of the concentrate and automatically adjusting the diluent flow during dispense so as to effect the correct ratiometric mix. The recognition means may be, for example, a bar code reader for reading a bar code affixed to the concentrate reservoir.

Embodiments of the invention will now be described by way of example only, with reference to the accompanying drawings in which;

Figure 1 is a perspective view of a disposable pump unit of the invention;

Figure 2 is a longitudinal cross-section of the disposable pump unit of Figure 1;

Figure 3 is a perspective view of a pump actuator for assembly with the pump unit shown in Figures 1 and 2;

Figure 4 is a cross-section of the assembled pump unit and pump actuator shown in Figures 1 to 3;

Figure 5 is a perspective view of the pump unit shown in Figure 1 additionally having a diluent inlet; and

Figure 6 is a similar view to Figure 5 but in which the pump outlet has an integral convoluted path mixing section.

Referring to Figure 1 and 2, a dual-chamber disposable pump unit 100 is shown. A fluid inlet 14 splits to feed each of the two pump cells 1a, 1b comprised in a rigid body 2 having on a substantially flat surface thereof an area 3 containing a chamber inlet port 4, the inlet port 4 being surrounded by a raised lip 5, and a concave cavity 6 defining one side of a pump chamber 7. The second side of the chamber 7 comprises a membrane 8 made of a flexible sheet material, e.g. low density polyethylene (LDPE), sealingly secured about its periphery to the aforesaid surface of the body 2 so as to enclose each fluid inlet area 3 and their respective concave cavities 6 such that fluid can pass from the inlet port 4, when open, to the respective concave cavities 6. Located in each concave cavity 6 of each pump chamber 1a, 1b is an array of chamber outlets 9. Each chamber outlet 9 is in fluid communication with a closable outlet port 10 surrounded by a raised lip 11. The flow paths from the two closable outlet ports 10 converge together into a single outlet 12. The two closable outlet ports 10 and the outlet 12 are together

sealingly enclosed by a membrane 13 comprising flexible sheet material, shown to be integral with the membrane 8, secured about its periphery to the aforesaid surface of the body 2.

Referring to Figure 3, a non-disposable pump-actuating unit 200 for the dual chamber pump unit 100 is shown. The actuating unit 200 comprises a rigid body 15 containing two concave cavities 16, each surrounded by a gasket seal 17. The concave cavities 16 and the gasket seal 17 are shaped such that they match the shape of the pump cells 1a, 1b so that when placed in contact with them they form a seal around the circumference of the pump cells 1a, 1b. Located within each cavity 16 is a compressed air inlet/exhaust port 18 defined in part by cross-shaped channels extending over a substantial basal area of the cavity 16. Also located within each cavity 16 is a solenoid-operated armature 19 which extends through the body 15 and into the cavity 16. A pair of solenoid-operated armatures 20 also extends through the body 15 adjacent to the cavities 16.

Referring to Figures 1, 2 and 4, the pump-actuating unit 200 is shown in Figure 4 to be releasably connected to the disposable pump unit 100 to form a complete pump. The cavity 16 in the unit 200 together with the membrane 8 forms an actuating chamber 21 connectable alternately to supplies of negative and positive pressure air *via* a passageway 22. Each cavity 16 in the pump-actuating unit 200 and its opposed cavity 6 in the disposable pump unit 100 together define a fixed volume of fluid that will be displaced on each cycle of the pump. The sequence of operation of the pump is that each armature 20 extends so as to urge the membrane 13 locally onto the respective raised lips 11 of the outlet ports 10 thus closing the pump chamber outlet, and the armature 19 is spaced from the membrane 8 such that the flow path between the inlet port 4 and the concave cavity 6 is open.

A first source of pump actuating fluid at a negative pressure, i.e. below ambient pressure, is connected to the actuating fluid port 18 via the passageway 22, the application of the negative pressure causing the flexible membrane 8 to be drawn towards and into the cavity 16 thereby drawing fluid into the latter from a reservoir (not shown) *via* the inlet 14 and the inlet port 4, the inlet port 4 being held open by the negative pressure tending to lift the membrane 8 locally away from the inlet port 4. The cross-shaped channels of the port 18 ensure that the membrane 8 can be drawn fully into the cavity 16 and prevents the membrane 8 from blocking the port 18 before the membrane 8 is substantially fully withdrawn into the cavity 16. When the membrane 8 is fully drawn into the cavity 16 and the volume defined by the cavity 16 and the cavity 6 is filled or substantially filled with the fluid to be dispensed, the armatures 19 and 20 are actuated such that armature 19 is moved towards the pump cell, locally pressing the membrane 8 against the raised lip 5 of the inlet port 4 to close the flow path between the inlet 14 and the pump chamber 7, and armature 20 moves away from the outlet port 10 allowing the membrane 13 to move away from the outlet port 10 of the pump cell outlet (12, Figure 1). Substantially at the same time, positive air pressure is applied to the membrane 8 *via* the port 18 which urges the membrane 8 towards and substantially fully into the cavity 6 whereby the fluid is pumped out through the outlet 12 *via* the outlet port 10. The pump filling/dispense cycle may then be repeated.

In operation, the two pump cells may be operated in opposite phase such that when one is dispensing the other is filling, the filling cycle preferably being faster than the dispense cycle such that there can be a slight overlap of the dispensing cycles to ensure constant output. If there are more than two pump cells then it is not necessary for the filling cycle to be faster than the dispense cycle.

Referring to Figure 5, a pump unit is shown which is similar to that shown in Figure 1 and operates in the same manner, but which has the additional feature of a diluent inlet array 23 through which a diluent enters the pump cell and mixes with the pumped fluid to pass with it through the pump cell outlet 12 whereby diluted fluid is dispensed. The flow of the diluent is controlled by means of an external control valve (not shown) which may be variable and controlled to give a constant ratiometric mixture of pumped fluid to diluent.

Referring to Figure 6, a pump unit is shown which is similar to that shown in Figure 5 and operates in the same manner. However, in addition, it comprises a mixing section 24 downstream of the point at which the diluent is added. Where the pumped fluid is of a high viscosity (e.g. above 10,000 centipoises) it becomes increasingly difficult to obtain a homogeneous diluted fluid; the convoluted path 25 of the mixing section 24 is designed to shear the viscous fluid and create turbulence to ensure that the two components mix fully.

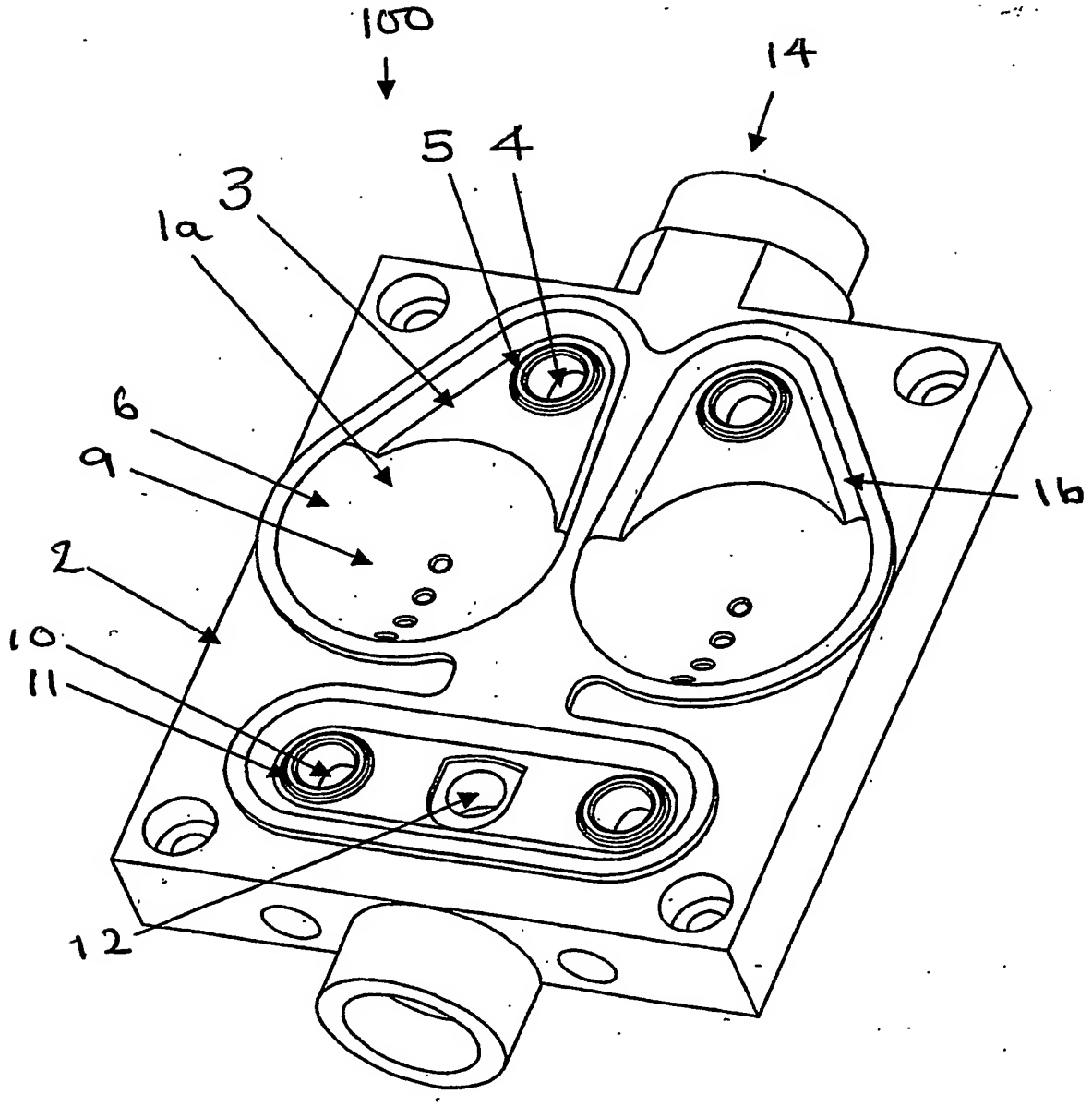

Figure 1

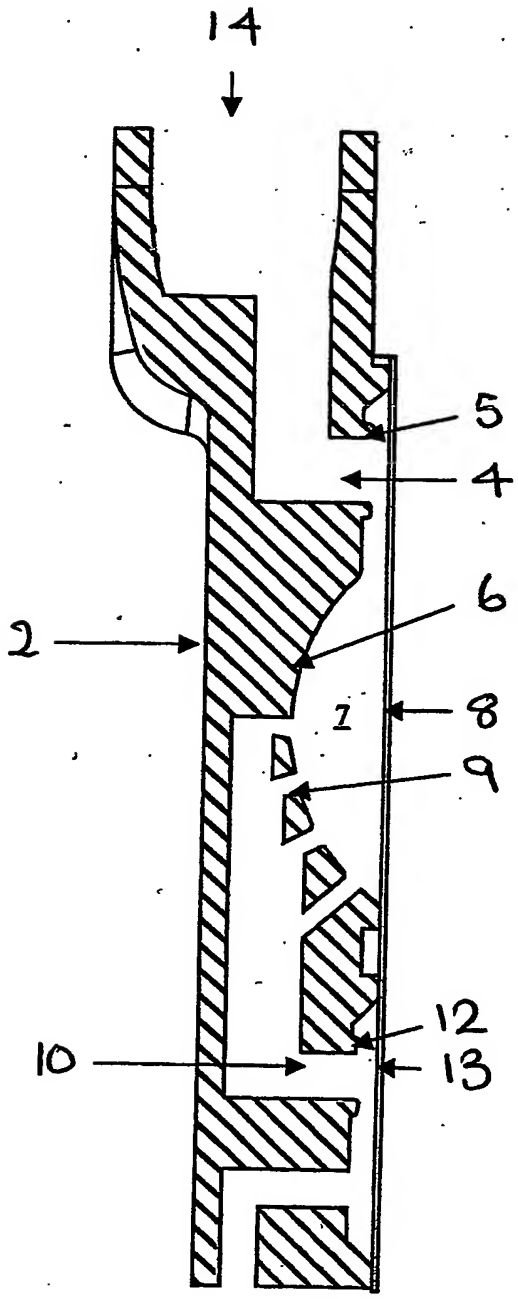

Figure 2

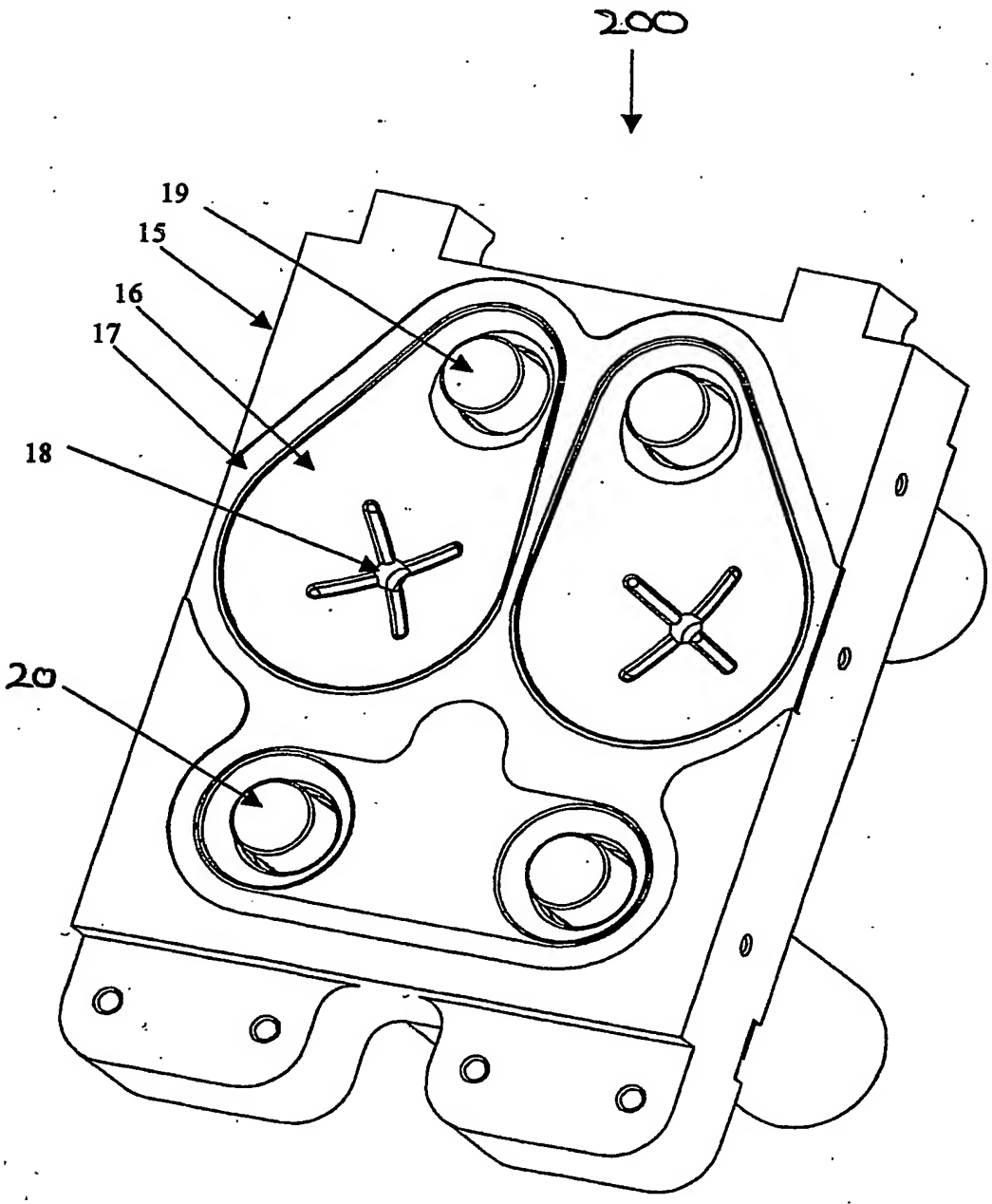

Figure 3

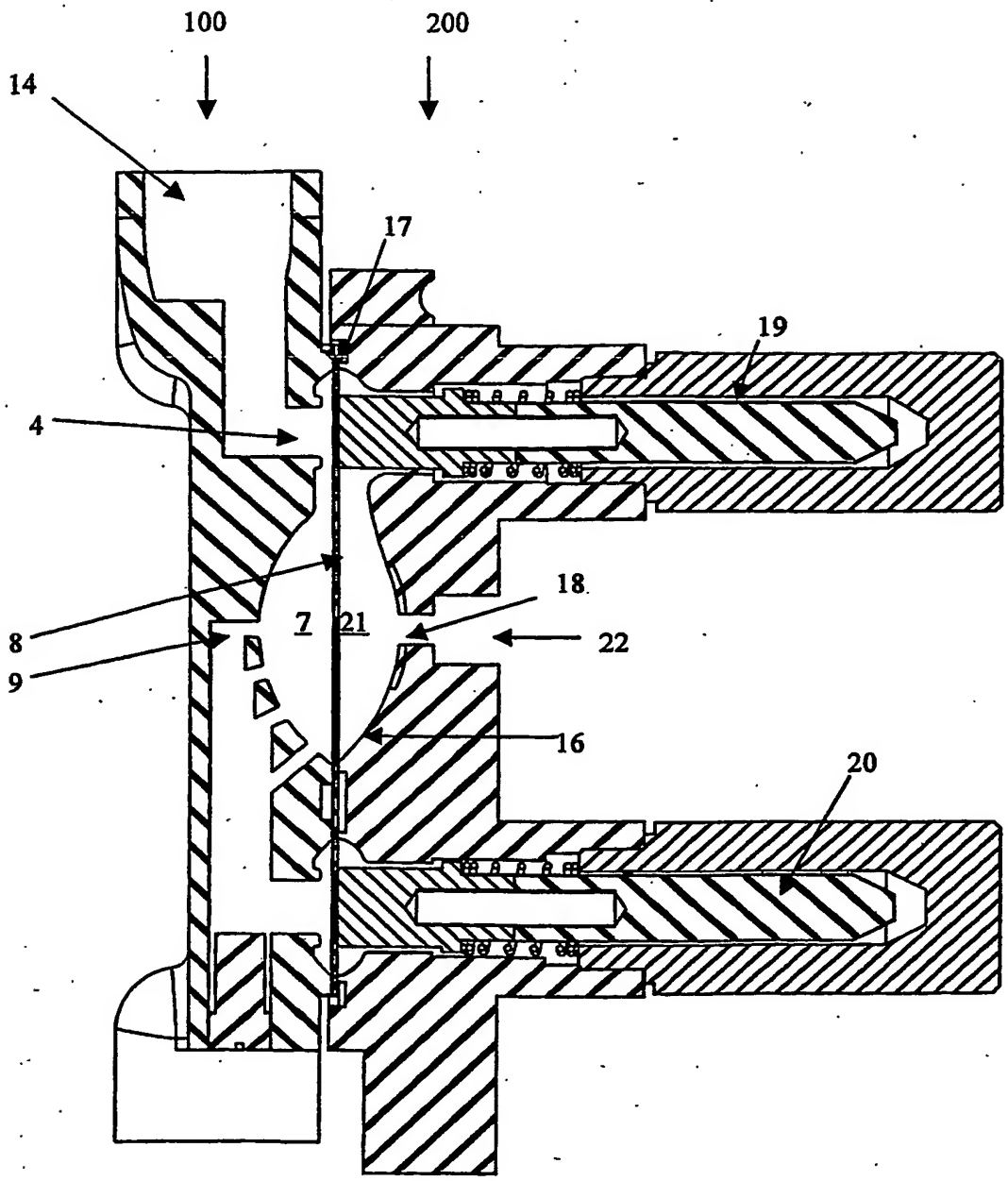

Figure 4

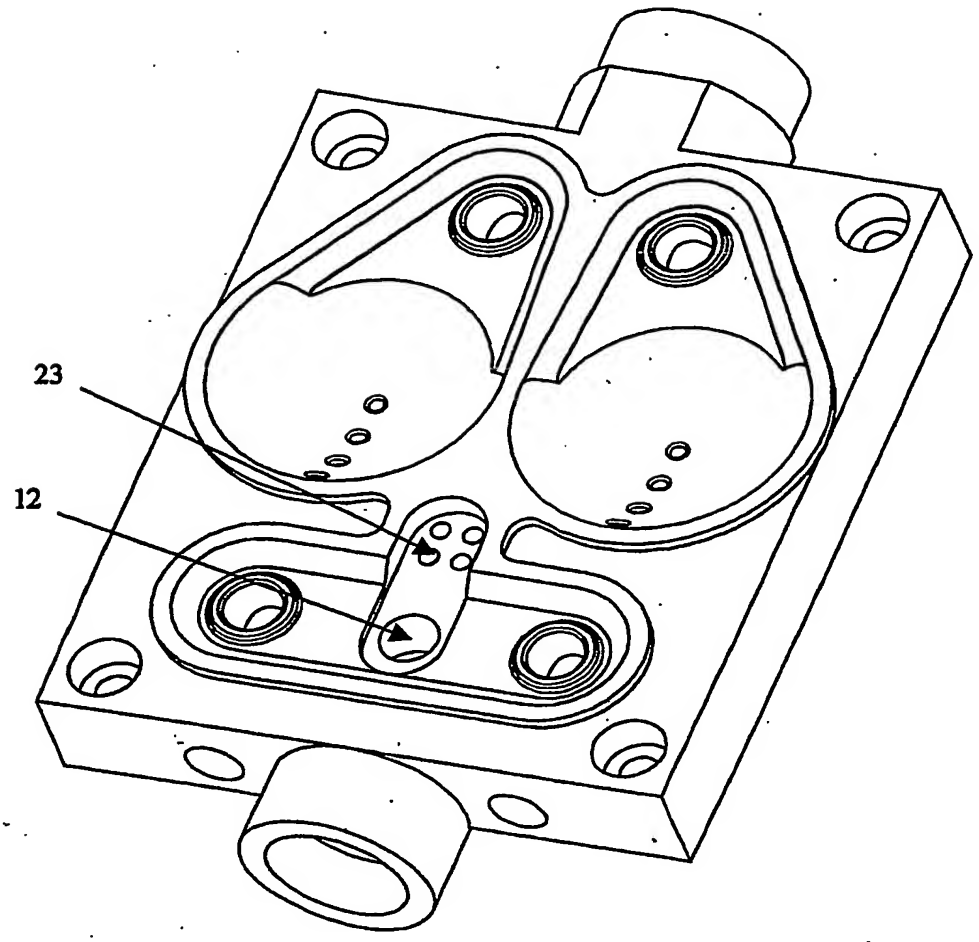

Figure 5

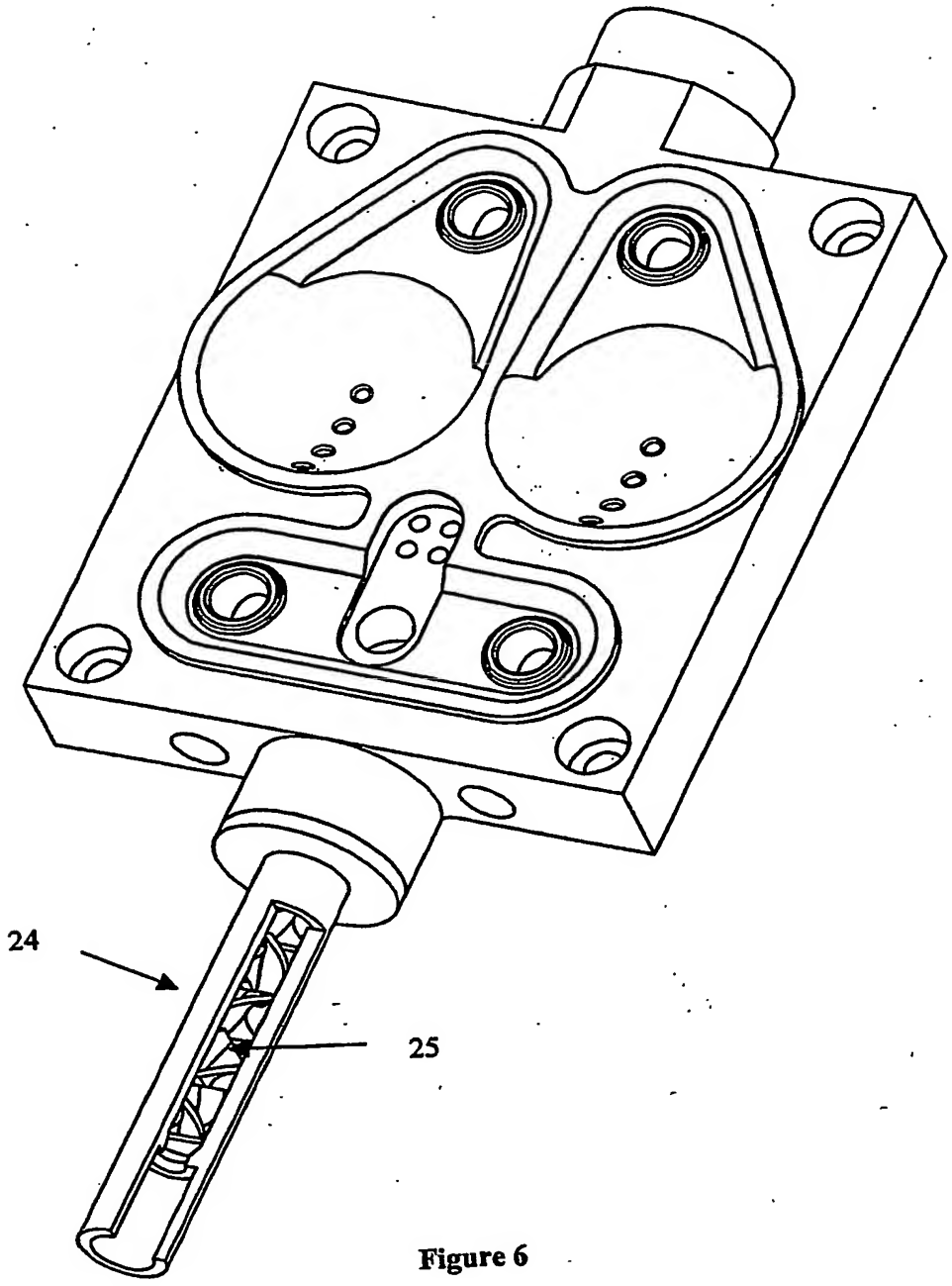

Figure 6

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